

Some Observations on the Reproductive Biology of *Sminthopsis virginiae* (Tarragon), (Marsupialia: Dasyuridae).

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ABSTRACT

Sminthopsis virginiae is polyoestrous, like other members of the genus, and appears capable of breeding throughout the year. The reproductive condition of females can be determined readily from examination of the pouch. Male-female interactions are agonistic except during oestrus when females become sexually receptive and attract males by calling. This elicits similar calling and searching behaviour in males.

The gestation period is in the range 13-20 days. Young are carried in the pouch for 55 days then left in a nest built under debris. They become independent of the mother at about 90 days old. Six types of call have been recorded: four of them involved in female-juvenile interactions.

INTRODUCTION

Sminthopsis virginiae (Tarragon), Family Dasyuridae, is a terrestrial, carnivorous marsupial of Australia and New Guinea, which grows to the size of a small rat (Plate 1). Though first described in 1847, it has remained little known and poorly represented in museum collections.

The only published notes on its biology are brief comments on its burrowing habits (Collett, 1887; Lumholtz, 1889) and its apparent preference for sunny areas in open forests (Tate, 1952). Nothing has been recorded on its reproductive biology and knowledge of reproduction in other members of the genus is restricted to field and laboratory studies of *S. crassicaudata* (Martin, 1965; Ewer, 1968; Godfrey, 1969a; Smith and Godfrey, 1970; Godfrey and Crowcroft, 1971; Morton, 1978b) and a laboratory study of *S. macroura* (= *S. larapinta*) by Godfrey (1969b). The capture of three adult *S. virginiae* in 1976 and 1977 and their successful breeding in captivity allowed a preliminary investigation of their reproductive biology.

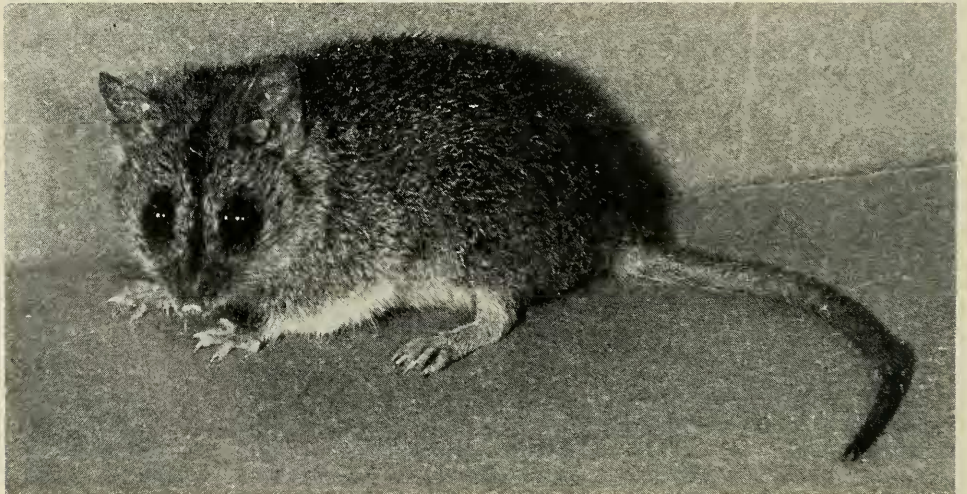


PLATE 1. Adult female *Sminthopsis virginiae* (Upper photo courtesy of Queensland Museum).

REPRODUCTION IN *SMINTHOPSIS VIRGINIAE*

MATERIALS AND METHODS

Two mature *S. virginiae* (A1 and A2, Table 1) were hand-caught on separate occasions near Kennedy, North Queensland (Lat. 18° 10'S; Long. 145° 56'E) in August, 1976. Both were found sheltering under logs on a railway easement which had a ground cover of eucalypt saplings and blady grass. The surrounding vegetation was a low, open forest of *Melaleuca viridiflora* and *Eucalyptus polycarpa* with dense understoreys of shrubs, grasses and leaf litter. A third mature sminthopsis was trapped in dense blady grass on a river flat on the Lockhart R., Cape York Peninsula (Lat. 13° 05'S; Long. 142° 30'E) in August, 1977 by the Queensland National Parks and Wildlife Service. All three are referable to nominate *S. v. virginiae* of Archer (in prep.). Five litters were subsequently born in captivity and three of these litters were reared to maturity (Table 1).

TABLE 1. Details of *Sminthopsis virginiae* individuals studied.

Animal	Sex	Approximate Date of Birth	Parents	Notes
A1	F	—	—	Collected Kennedy
A2	M	—	—	Collected Kennedy
A3	F	23.x.76	A1, A2	
A4	F	23.x.76	A1, A2	
A5	F	23.x.76	A1, A2	
A6	M	14.iv.77	A1, A2	
A7	F	14.iv.77	A1, A2	
A8	M	—	—	Collected Lockhart R.
A9	M	29.xi.77	A3, A8	
A10	F	29.xi.77	A3, A8	
A11-A15	?	27.xii.77	A4, A8	Eaten (?) 13.i.78
A16	?	30.i.78	A4, A8	Eaten (?) 12.ii.78
A17	?	30.i.78	A4, A8	Died 27.iii.78

Adult *S. virginiae* were normally housed individually in glass aquaria from 60 x 30 x 30 cm to 140 x 45 x 45 cm in size. Siblings were occasionally kept together after weaning. Cages were floored with soil and leaf litter and provided with logs, bark sheets or dry grass for shelter. The animals were fed a finely minced mixture of heart, liver, brain, steak, dog biscuit and egg, similar to that described by Collins (1973). This was supplemented occasionally with insects, frogs, lizards, snakes and mice. Fresh water was supplied daily.

Behavioural observations were made under dim artificial lighting over periods of one to four hours at various times between 1900 hr and 0400 hr. In addition, the animals were kept in the author's study for over two years, enabling daily, casual observations of activity. Particular emphasis was placed on recording sexual activity. It is estimated that several hundred hours were spent observing their

behaviour. Tape recordings of vocalisations were made during observation periods using a Hitachi D500 cassette recorder and a Tandberg 11 tape recorder with a Sony ECM33 microphone.

Development of the pouch young was monitored during the rearing of three litters born 29-11-77, 27-12-77 and 30-1-78 (Table 1). The first two litters were allowed to develop with minimal disturbance. The observations of developmental stages summarised in Table 2 were made with the unaided eye on animals attached to nipples but everted from the pouch. Measurements of pouch young and adults were made with vernier calipers and dividers. Crown-rump length (CRL) was measured between 1 and 25 days of age: after this the wriggling of the young introduced serious errors. Head length (HL) was measured from 18 days old onward, except between 50 and 60 days old. During this period, either the young could not be removed from the pouch without injury, or they had just been left in the nest and were particularly sensitive to disturbance.

RESULTS

SOCIAL AND MATING BEHAVIOUR

Adult male and female *smynthopsis* were housed separately, as they squabbled continuously when kept together. This was especially true of the wild-caught animals. The only notable exception to this occurred in June, 1978 when A4 and A5 (sibling females) were accidentally allowed into the same cage and exhibited little of the expected aggressive behaviour. A6 (non-sibling male) was introduced to their cage the following day and the three animals were housed together for four months without the usual incessant threat calls and fighting. However, while it was common to find the females sleeping together, the male was never observed sleeping with either of them and was regularly chased and bitten if he ventured close to them. There was no evidence of sexual activity at any stage.

During aggressive male-female interactions, both animals utter a series of drawn-out, rasping 'tzzzz' calls, increasing in intensity as the distance between them decreases. At the same time, the ears are flattened, the teeth bared and the body pressed close to the ground. It is usual for the male to approach the female and be chased and bitten by her if he comes too close. However, during brief periods of sexual receptivity, the female becomes very active and scurries about, sniffing the air while standing erect and emitting loud 'tsst' calls (referred to here as oestrous calls) at irregular intervals of 2 to 10 seconds. Nearby males respond with similar calls and likewise scurry about, sniffing the air, and apparently searching for the calling female. The male's call could not be distinguished by ear from the female's and the *smynthopsis* do not appear to distinguish between them either, since both sexes will respond to tape recordings of male or female oestrous calls and even to a human imitation of them. Male *smynthopsis* were never observed to initiate a bout of calling.

The reciprocating call routine usually starts at dusk and lasts from one minute to several hours. Calling ceases immediately a member of the opposite sex is introduced to the cage. Once together, mating is virtually immediate, and no oestrous calling is heard while the animals are together.

Once the male contacts a receptive female, there are few preliminaries to mating. The male commonly rushes over to the female, seizes her by the scruff of the neck, and attempts copulation immediately. If he is wary of approaching her, the female may sidle up to him with ears depressed, fur flattened, body pressed close to the ground, and without uttering the usual threat call. The male responds by baring his teeth and uttering a mild threat call until the female is close, when a brief olfactory inspection is followed by copulation.

Copulation is violent and prolonged. Early in the study, matings were interrupted after two to three hours because it was feared the female might be killed if unable to escape. However, in six later matings, the animals remained together overnight. Matings were not timed regularly, but one lasted over seven hours. During mating, the male *sminthopsis* grasps his partner firmly around the lower abdomen with his forepaws and rubs his chin vigorously along her back and nape. This rubbing appears to induce passiveness in the female. Copulation is interrupted at irregular intervals of 15 seconds to 10 minutes either by threat calls and struggling from the female or by brief bouts of genital licking by both animals. When the female struggles, the male wrestles her into submission, intensifies his neck-rubbing, and often grips the female's neck with his teeth, causing extensive hair loss and scarring.

If left together overnight, the *sminthopsis* usually squabble the next day, particularly if the male shows further sexual interest in the female. It was suspected that one night of uninterrupted mating might inhibit further oestrous calling by the female. However, females showed further calling in four cases out of six in which a pair were left together overnight and separated the following day.

OESTROUS CYCLE

Detailed records of oestrous calling were kept over a two year period. Bouts of calling lasting from one to seven days were associated with a marked swelling, flushing and lubrication of the vagina and with sexual receptivity. The time between the first day of one bout of calling and the first day of the next bout has been used as an estimate of the length of the oestrous cycle.

A5 came into oestrus six times between December, 1977 and June, 1978 at intervals of 31, 29, 32, 40 and 39 days. She was mated on every occasion but apparently failed to produce young. A4 showed two consecutive cycles of 34 and 29 days duration before producing two young in December, 1977. A3 showed a single cycle of 34 or 38 days before producing young in November, 1977: the doubt arises from difficulty in determining which animals were calling one evening.

Oestrous calling was noted in every month except August and September and litters were born in January, April, October, November and December.

Periods of anoestrus from two to six months duration were common. Lactating females remained anoestrous until the young were close to weaning or died. For instance, A1 produced two litters which were both weaned at about 80 days of age and she was noted calling at 75 and 89 days respectively. During the second half of 1978 most females showed little or no oestrous calling and those that did were hostile toward the males when mated. No litters were born after January, 1978. A dietary problem may have caused this as the sminthopsis were receiving no live food at this time and all died eventually during 1978.

POUCH CHANGES DURING OESTRUS AND PREGNANCY

The pouch of juvenile and anoestrous *S. virginiae* is crescentic with an anterior opening (Figure 1a), but its shape changes markedly during the oestrous cycle and gives an indication of the reproductive status of females.

Between 10 and 20 days after the onset of oestrus (as indicated by oestrous calling) the pouch walls become swollen and flushed red while the anterior wall becomes prominent (Figure 1b). This is followed closely by the development of

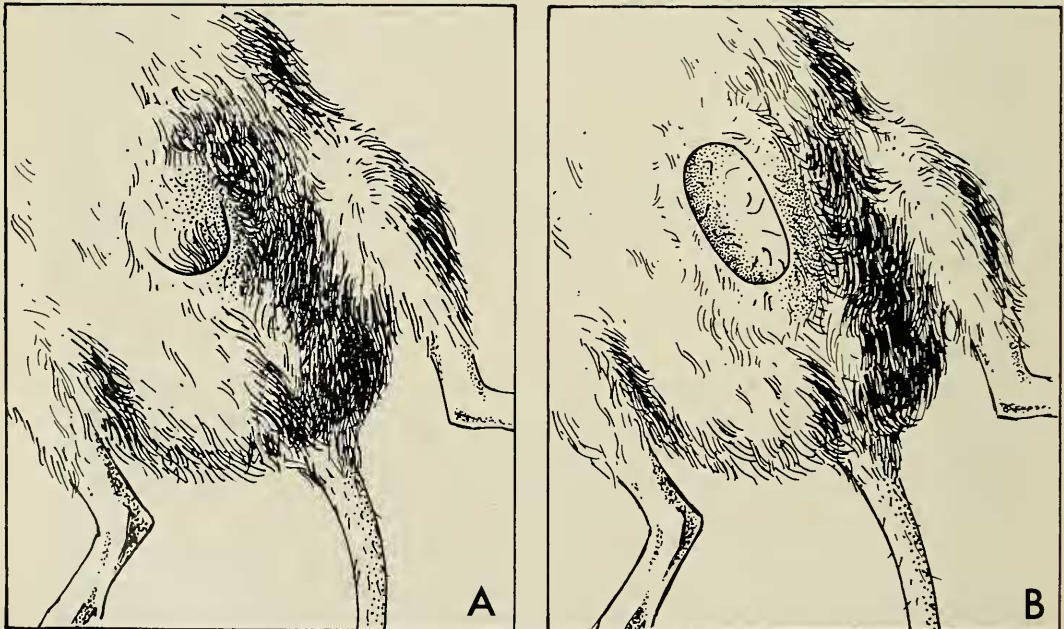


FIG. 1. Pouch configuration in *Sminthopsis virginiae*
A: juveniles and anoestrous females
B: oestrous females and those carrying young

skin folds and papillae in the mammary region, accompanied by a thinning out of the dense patch of hair which entirely obscures this area in regressed pouches. The eight nipples, though remaining very small, become pink and finally bright red for a day or two about 18-22 days after the onset of oestrus.

In females that do not bear young, the pouch develops these features between 10 and 20 days and regresses to its original condition between 20 and 30 days after the onset of oestrus. However, the pouch does not regress until after weaning in females that produce young. Rather, its walls develop markedly — particularly the anterior lip — and the nipples on which young are suckling become pale, swollen and elongate, remaining like this until the young are weaned. Nipples not being suckled remain small and pale.

The pouch regresses after weaning to the condition shown in Figure 1a, except that the anterior lip remains as a low ridge and the pouch walls are slightly swollen, though pale. This condition persists after several months of anoestrus and distinguishes females which have borne young from those which have not. In the latter the pouch walls are thin and pale and there is no anterior ridge. Post-weaning regression of the pouch takes 15-20 days.

GESTATION PERIOD

The gestation period could not be well defined in this study. After three matings the pouch was examined daily between days 10 and 22 and every 2-3 days thereafter. No young were found, so inspections were limited to once every 2-3 days after later matings to reduce disturbance of the adults. From 17 matings only 5 litters were observed. Gestation periods for three of these were 13-16, 16-19 and 17-20 days.

GROWTH AND DEVELOPMENT OF THE YOUNG

Only three litters were available for study of the pouch young and only one of these litters was reared to maturity. Crown-rump length of three *sminthopsis* is plotted against age in Figure 2a for the first 25 days of development. Head-length versus age is plotted for the same three animals from 18 days to adulthood in Figure 2b. Unfortunately, the only animal for which a reasonably complete set of measurements was collected, (A9), developed with a deformed snout. This is reflected in its relatively short adult head length but the deformity appears not to have affected markedly the earlier stages of development.

The major developmental stages of the pouch young are summarised in Table 2. Many features could have been distinguished somewhat earlier had it been possible to remove young at regular intervals for closer examination. However, Table 2, in conjunction with Figure 2, does provide a means of estimating the age of pouch young.

The young were first left on their own in the nest at 55-56 days of age and began exploring outside it about 10 days later. They were first seen eating solid

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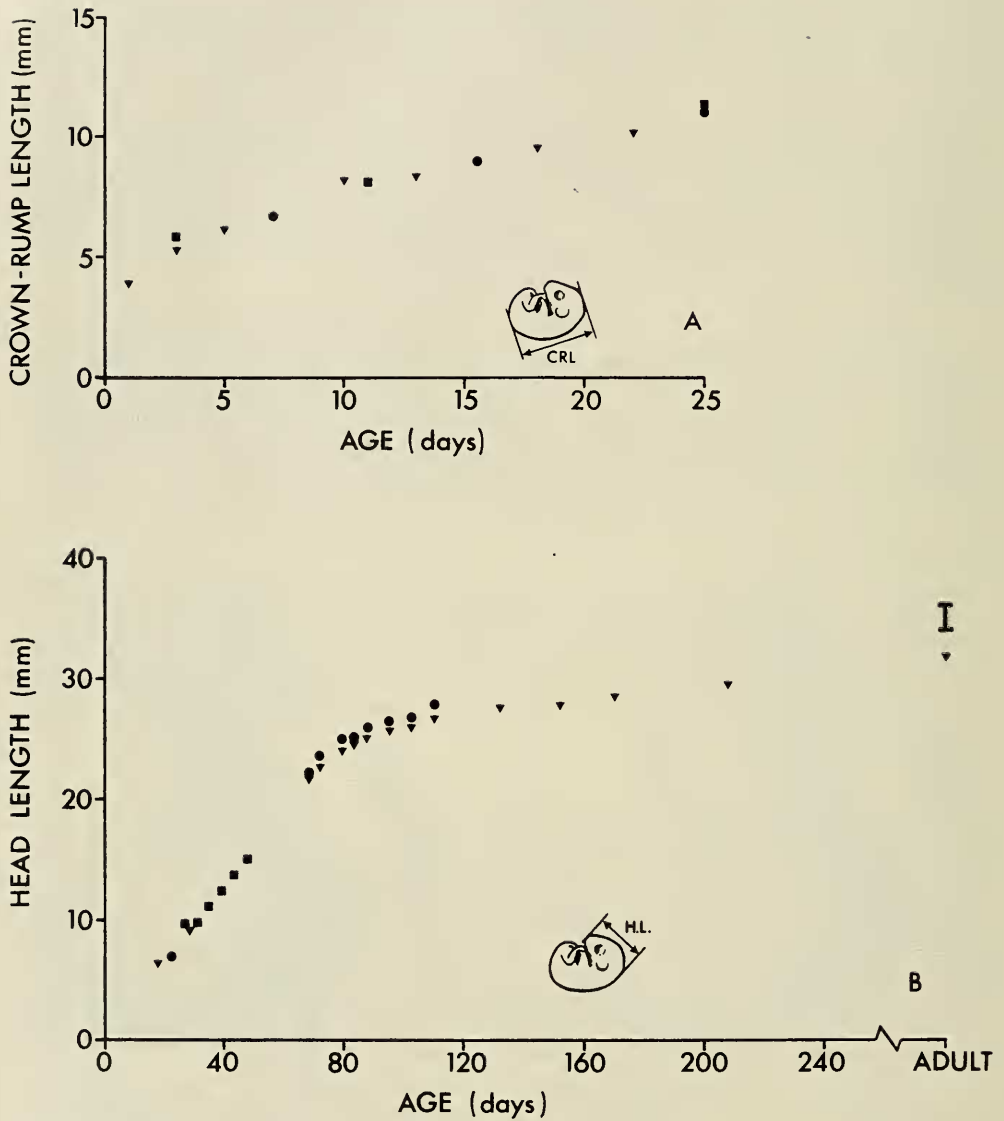


FIG. 2. Growth curves of *Sminthopsis virginiae*
 A: Crown-rump length (CRL) against age of pouch young
 B: Head length (HL) against age of juveniles
 ▼ - A9; ● - A10; ■ - A11
 I - Range of head lengths in adults

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TABLE 2. Developmental stages of pouch young of *S. virginiae*.

AGE (days)	Forelimbs	Hindlimbs	Eyes	Mouth	Ears	Fur
0	Prominent. No finger buds.	Not visible.	Not visible.	Circular.	Not visible.	Naked. Pink.
5			Minute black spots.			
10		Approx. 2/3 of forelimb length.				
13	Finger buds appear.	Feet and toe buds appear.				
16			Transparent corneal disk appears.			
18	Digits separated.					
20	Elbow and wrist movements seen.		Eyelids begin to form. No slit.		Pale bulge on head.	
22		Toes separate. Knee and ankle movements seen.				Some grey pigmentation on head.
25	Fingers able to grip pouch hair.					
28	Claws visible on fingers.		Eyelid slit forms. Cornea visible below eyelids.	Mouth slit reaches to below front of eye.	Pinna developing.	Hair appearing on head. Hair papillae all over body.
34					External pinna measurable — 2mm deep.	
38		Claws visible on toes.				Vibrissae 2-3mm long. Head and dorsum with thin, dark hair. Sparse hair on rump and venter.
40-45				Mouth slit opening to front of eye.		
50-55				Mouth slit opening to back of eye.	External pinna 5-6mm deep.	Completely furred. Light hair on feet, forelimbs and venter. Tufts on ears.
56-58			Eyes open.			

food at 74-78 days old and were weaned between 80 and 90 days of age. By this time, they had a snout-vent length of 85-90 mm, a total length of 185-190 mm and a weight of 18-20g. They grew slowly after weaning and attained their adult size of 120-130 mm snout-vent length, 230-240 mm total length and 40-50g weight at about 200 days.

SEXUAL MATURITY AND LONGEVITY

The earliest age at which oestrous calling occurred in females was 230 days (A7). A3, A4 and A5 were first noted calling at 347, 347 and 413 days old respectively. The scrotum of A9 reached adult size at about 200 days old. Thus a very rough estimate of about 200 days can be suggested for sexual maturity of both sexes in *S. virginiae*.

Laboratory-bred animals reached adult size at about 200 days old. A1, A2, and A8 (all mature when caught) lived 480, 360 and 300 days respectively in captivity. Thus a lifespan of at least two years is indicated.

NESTING AND BURROWING

Nest-building activity was seen only in female sminthopsis after carrying young for 50-55 days when they were getting too big to be carried in the pouch. At such times the females gathered leaves, grass and bark which were arranged in a rough saucer-shaped depression under a log or piece of bark. Males and females without young showed little or no nest-building activity: at most they would gather a few pieces of grass or leaves to form a thin ground cover under a log.

Attempts to stimulate burrowing activity by providing the sminthopsis with deep, compacted soils were unsuccessful in both males and females at all stages of the oestrous cycle. This was the case regardless of whether or not shelter was provided. In contrast, native rodents (*Pseudomys delicatulus*), tested under similar conditions, burrowed extensively.

VOCALISATIONS

Adult sminthopsis without young produce relatively few calls apart from a variety of very faint squeaks and snuffles while eating and exploring. However, vocal communication plays an important role in mating and rearing of the young.

The oestrous and threat calls have been described above. The female sminthopsis also utters calls similar to the oestrous call, but lower in intensity, in three different contexts. When entering the nest or when passing it while the young are hidden there, the female utters one or two faint "tsst" calls. It is not known if the young respond to these calls. If the mother is suckling the young in the nest and one strays away, she utters a louder "tsst" to which the young responds by scampering rapidly back into the nest. A call of the same intensity is uttered when the mother carries the young on her flanks and one falls off. The

juvenile emits a very loud, rapid chatter — “tz-tz-tz-tz-tz” — to which the female responds by stopping, turning to the juvenile and uttering the “tsst” call while lowering her rump. The juvenile runs to the mother, who assists it in climbing onto her flanks by pushing it up with her nose. As the young approach the age of weaning, the mother increasingly ignores their distress calls, forcing them to run after her. The rapid chatter of juveniles disappears a few weeks after weaning.

DISCUSSION

The oestrous call and its associated behaviour described here have not been reported for any other species of *Sminthopsis*. However, S. van Dyck (pers. comm.) has observed very similar behaviour in *S. murina*. He describes their calls as a “wheezy, husky ‘chee’” on the first few days of calling, changing to “a succession of sharp ‘ts-ts-ts-tsst’” calls after about five days in unmated females. It is possible that this behaviour is more widespread among members of the genus but has not been noted where animals were kept as pairs or small groups. Morton (1978a) found that *S. crassicaudata* had a very loose social organisation in the wild and the observations reported here suggest that *S. virginiae* also conforms to this pattern. Thus, oestrous calling and its associated searching behaviour may be a mechanism for bringing these apparently solitary animals together for mating in the dense undergrowth where they live.

S. virginiae is polyoestrous, as are the other two members of the genus studied to date (Woolley, 1973), and this study showed also year-round sexual activity. This is rather surprising given the markedly seasonal nature of their sub-tropical habitat and the prevalence of wet-season breeding in many animals of this region (pers. obs.). Interestingly, Aslin (1975) found both wild and captive *Planigale maculata* (= *Antechinus maculatus*) breeding during the dry season in sub-tropical northern Australia. It is possible that more observation may show both species to be predominantly summer breeders.

The form of the pouch in juvenile and non-oestrous adult *S. virginiae* fails to conform to any of the four pouch types described from dasyurids by Woolley (1974). However, at some stages of the oestrous cycle and during pregnancy, it conforms to Woolley's Type 3 pouch, typical of both non-pregnant and pregnant *S. crassicaudata* and *S. macroura*. The marked changes in pouch conformation in *S. virginiae* appear to make it a much better indicator of the reproductive state of females than is the case for *S. macroura* (Godfrey, 1969b).

The observation that male *S. virginiae* use a neck grip during copulation is of interest since Ewer's (1968) observations indicated that this is not the case in *S. crassicaudata*. Ewer drew upon this fact and the differences in young-carrying behaviour between *Sminthopsis crassicaudata* and many placental mammals (which use a neck grip during copulation and when carrying young) to suggest that the

two neck-grip behaviours are closely correlated. Such a supposed correlation breaks down in the case of *S. virginiae*.

Burrowing behaviour has been reported twice for *S. virginiae*. Both Collett (1887) and Lumholtz (1889) reported that the single animals they collected were dug out of the ground. All efforts to elicit burrowing in captivity during this study were singularly unsuccessful. They did not even turn over the soil or dig in the corners of their cages. Doubt therefore remains as to whether *S. virginiae* does in fact burrow in the wild, though it may shelter in the burrows of other animals.

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